Missouri Botanical Garden

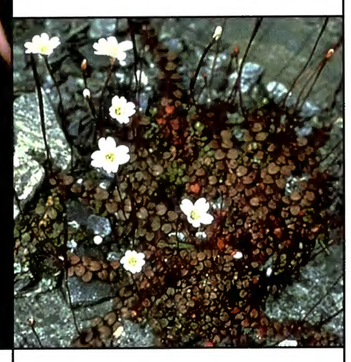
Research: Onagraceae

▲ **Chamerion angustifolium**—Pollination in *Chamerion angustifolium* was documented in the first scientific publication on pollination biology in 1793. The flowers open from the bottom of the flowering stalk upwards, first functionally male and presenting pollen-filled anthers, later becoming female, producing nectar and the open four-lobed stigma. Pollinators visit the lowest flowers first, from which they get nectar rewards, gradually visiting other flowers up the stem, eventually reaching male flowers with no nectar that dust the insects with pollen, which they then carry to the lower (female) flowers of the next stem. Primary pollinators are bees, which produce a prized fireweed honey. Although formerly included in *Epilobium*, the fireweeds are very distinct, based on both morphology and molecular data, and now are considered a separate genus. [W. L. Wagner]

▶ **Oenothera deltoides—Mohawk Dunes, AZ** *Oenothera* (here *O. deltoides*) provides the common family name—a primrose-like flower blooming at dusk. Oil from its seeds contains an omega-6 essential fatty acid, gamma-linolenic acid (GLA), which has been studied for treatment of various disorders, including eczema, diabetes, and several others. However, conclusive evidence for its efficacy is still lacking. [R. Raguso]

◀ **Hyles lineata (hawkmoth)** Thanks in part to the "sticky" viscin threads on the pollen, this hawkmoth (*Hyles lineata*) is heavily dusted in Onagraceae pollen, making it an effective vector for carrying pollen from one flower to another. The moth's long tongue (proboscis) allows it to reach nectar in the deep floral tubes of the *Oenothera* flowers it targets. [D. Artz]

▼ **Epilobium** The largest genus in Onagraceae with 165 species, *Epilobium* has radiated into a great diversity of habitats in montane and boreal regions worldwide. Its small flowers are generally unspecialized, and many species regularly self-pollinate. A particularly remarkable radiation is found in New Zealand, including this mat-forming species, *E. brunnescens*. [P. Raven]

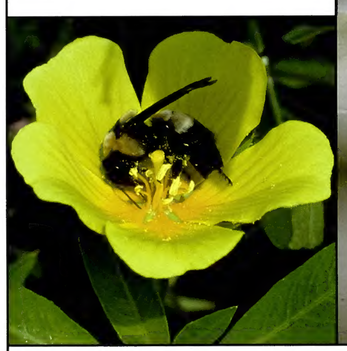


▶ **Oenothera deltoides—Bouse, AZ** Among the species of Onagraceae adapted to dry regions of southwestern North America, *Oenothera deltoides* is a member of the so-called "bird-cage" evening primroses. These plants dry into a form reminiscent of a bird cage; the plant eventually breaks and tumbles in the wind, effectively dispersing its seeds. [R. Raguso]

▲ **Fuchsia magellanica—Valdivia, Chile** *Fuchsia*, perhaps the most widely cultivated genus in the family, became popular in Europe soon after the early voyages of discovery to South America. Attracted by flowers in striking shades of red, orange, purple, and pink, professional and amateur growers alike have grown and hybridized these plants in a myriad of forms, and recent cold-hardy varieties have extended their use into temperate gardens. [R. Raguso]

▼ **Clarkia speciosa** Species related to this one comprise *Clarkia* section *Godetia*, a group of species grown since the early 19th century for their spectacular flowers. As a young teenager roaming the semi-wild Presidio area of San Francisco, Dr. Peter Raven spotted and collected a beautiful *Clarkia*, which he later described with his future professor Harlan Lewis as a rare new species, *C. franciscana*. [P. Raven]

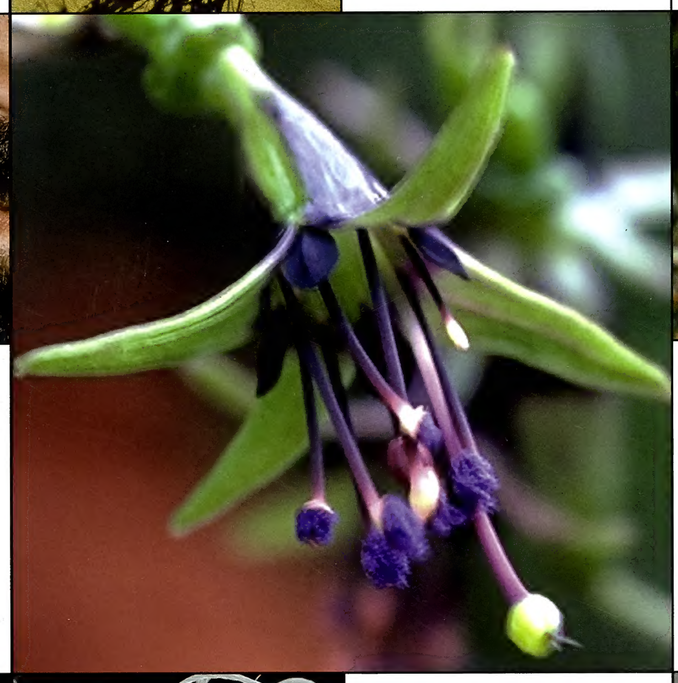
▼ **Ludwigia** The first branch off the Onagraceae "tree," *Ludwigia* has been a lineage separate from the rest of the family for about 80 million years. This great age is reflected in its geographical distribution, with distinctive sections found in wetlands of sub-tropical South America, Africa, Asia, and North America. [Ching-I Peng]



▲ **Fuchsia** The primary radiation of *Fuchsia* is found in the Andes of South America and montane Central America. The Andean uplift played an important role in the diversification of this and many other groups by providing new habitats and isolating previously continuous ranges. A similar radiation took place in hummingbirds, their primary pollinators. [D. Dod]

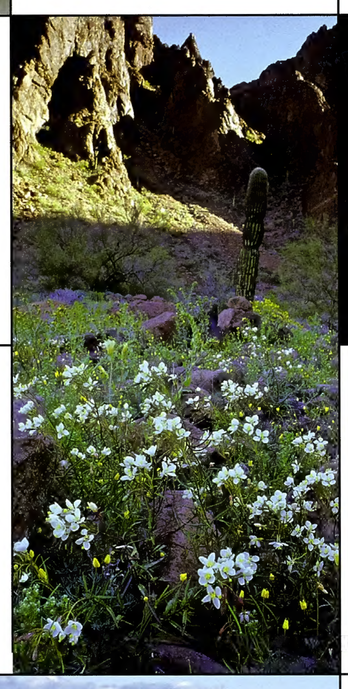
◀ **Hauya elegans** Trees are rare in Onagraceae, and *Hauya elegans* from southern Mexico and Central America is one of the largest (to 25 m). It produces large, fragrant white flowers that are pollinated by moths and probably bats near dusk. Note the web of viscin-thread connected pollen between stamens. [W. L. Wagner]

▲ **Hawkmoths** As one of the most charismatic and mysterious pollinators, they visit flowers of *Oenothera* (here, *O. hartwegii*, presented by intrepid botanist and fragrance analyst Robert Raguso) just as they open at dusk. Attracted by volatile compounds released by the striking flowers, hawkmoths are able to reach nectar at the base of long floral tubes using their equally long proboscises (tongues). [C. Hedgcock]

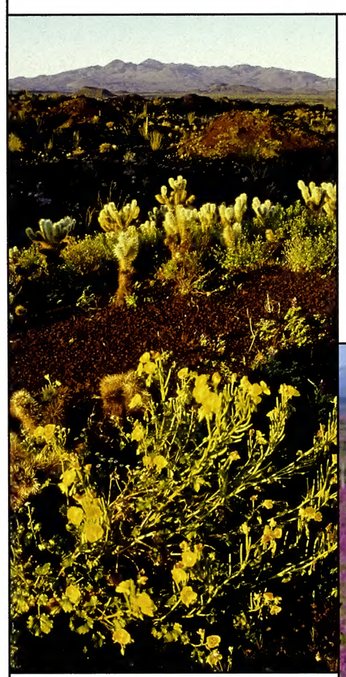


◀ **New Zealand Fuchsia** One section of *Fuchsia* occurs in New Zealand and Tahiti, reflecting ancient connections that existed among the southern continents, including Antarctica. *Fuchsia excorticata*, with its distinctive blue pollen, is pollinated by birds, in this case by honeyeaters, since hummingbirds—primary pollinators of New World species—do not occur in New Zealand. [P. Hoch]

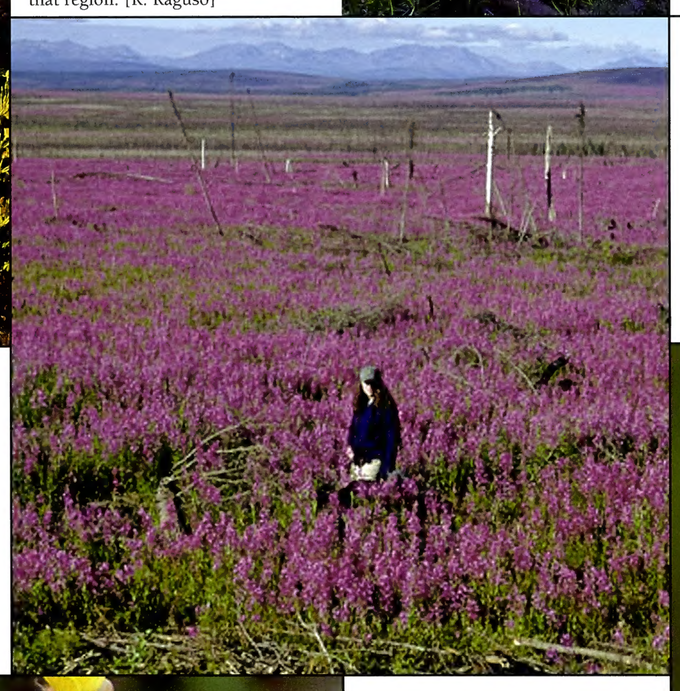
▶ **Eremothera refracta—Kofa Mts. Nat. Wildlife Refuge, AZ** *Onagraceae*, the evening primrose family, includes 22 genera and 657 species distributed on all continents except Antarctica, but with the highest number and diversity of species in western North America. By studying all aspects of the family—morphology, cytology, embryology, pollination biology, ecology, etc.—and using modern techniques of molecular systematics and phylogenetics, Dr. Peter Raven, the president of the Garden, and his students and colleagues have provided both a clear understanding of the species and genera, their characteristics and distribution, and a platform from which to carry on exciting new evolutionary studies. Much additional information on Onagraceae can be found on the website developed with Warren L. Wagner at the Smithsonian Institution: http://botany.si.edu/Onagraceae/. [R. Raguso]



◀ **Oenothera glaucifolia pollen** This scanning electron micrograph of *Oenothera glaucifolia* pollen shows several distinctive features, including the 3-cornered shape, unusual wall structure, and viscin threads that arise from the pollen wall. These features help identify Onagraceae pollen in the fossil record, and date the origin of the family to about 93 million years ago. [J. J. Skvarla]

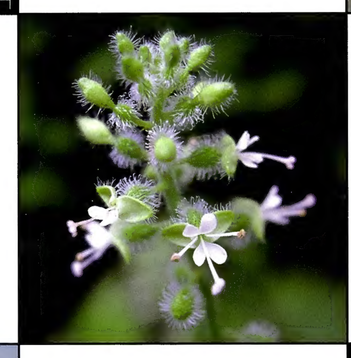


◀ **Chylismia cardiophylla—Pinacate Biosphere Preserve, Mexico** Many seemingly barren desert regions in southwestern North America burst with spectacles of flowering following the infrequent rains, and many species of Onagraceae (like this *Chylismia cardiophylla* in Sonora, Mexico) are among these beautiful blooms. The combination of habitat and pollinator specialization has driven a radiation of the family in that region. [R. Raguso]



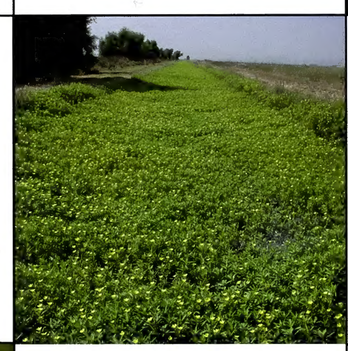
▲ **Clarkia** Harlan Lewis (1919–2008), a pioneer in incorporating cytogenetics into plant systematics and doctoral dissertation advisor to Dr. Peter Raven, was the acknowledged expert on *Clarkia*, making it a model for evolutionary studies. Now frequently found in horticulture, *Clarkia* evolved primarily in the species-rich Mediterranean-climate region of California. [E. S. Ross]

▶ **Circaea** Commonly known as enchanter's nightshade, *Circaea* (from Circe, enchantress of *Odyssey* fame) is unusual in Onagraceae in having only two sepals and two petals, and being distributed mainly in Eurasia. The small fruits (here, of *C. cordata*) are covered with tiny hooked hairs and disperse by catching in the fur of passing animals. [D. E. Boufford]

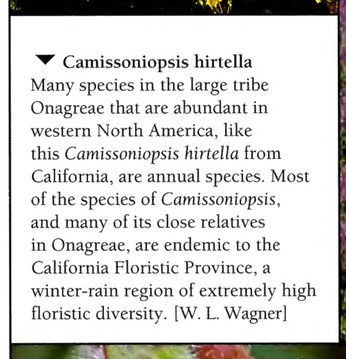


▲ **Megacorax gracielanus—Durango, Mexico** First discovered in 2001 and described in 2002, this distinctive genus *Megacorax* is known only from the Sierra de Coneto in central Durango, Mexico. This new genus, now known to be related to *Lopezia*, was the first described in almost a century in Onagraceae, and fittingly was named to honor Dr. Peter Raven; *mega-* (large) + *Corvus corax* (the raven). [D. Hardin]

▶ **Ludwigia hexapetala—in an irrigation canal in CA** Invasive species threaten native biota, and are difficult and expensive to control. *Ludwigia hexapetala*, native to southern South America, has invaded irrigation canals in California, growing so densely that it completely covers the water. It threatens rice and other crops and impedes water flow, promoting the growth of disease-carrying mosquitos. [P. Hoch]



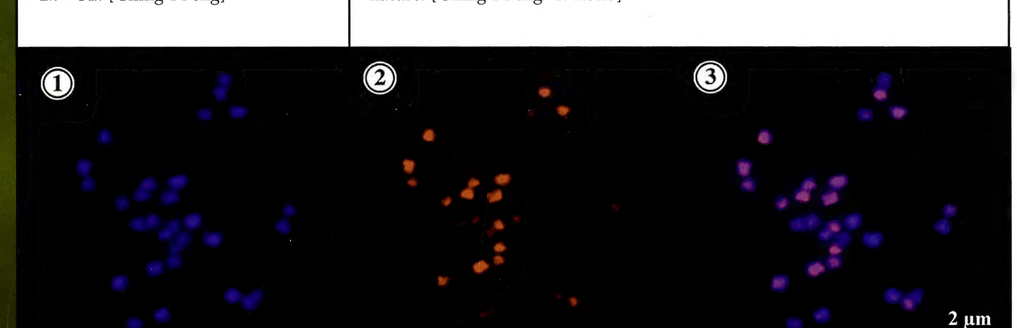
▶ **Lopezia concinna** *Lopezia* are a group of 22 species almost entirely endemic to Mexico that display a remarkable diversity of both chromosome numbers and floral morphologies, attracting a diversity of pollinators. Flower flies visiting the delicate orchid-like flowers of *L. concinna* are plastered with pollen by the flower's spring-loaded pollen release system. [P. Hoch]



▼ **Camissoniopsis hirtella** Many species in the large tribe Onagreae that are abundant in western North America, like this *Camissoniopsis hirtella* from California, are annual species. Most of the species of *Camissoniopsis*, and many of its close relatives in Onagreae, are endemic to the California Floristic Province, a winter-rain region of extremely high floristic diversity. [W. L. Wagner]

◀ **Ludwigia suffruticosa** Most species of *Ludwigia* are polyploid, a condition where the entire set of chromosomes is duplicated, in some species of *Ludwigia* up to eight times; this may reflect in part the great age of the genus as an independent lineage. *Ludwigia suffruticosa*, found on the coastal plain of southeastern North America, is tetraploid, with $2n = 32$. [Ching-I Peng]

▼ **Ludwigia spathulata—GISH** Study of Onagraceae chromosomes has provided unique insights into plant evolution for more than a century. One recent method – genomic *in situ* hybridization (GISH) – combines molecular with microscopic techniques to characterize chromosomes. These images depict the chromosomes of *Ludwigia spathulata*, a tetraploid species thought to be hybrid between the diploid *L. palustris* ($2n = 16$) and another unknown diploid. Image 1 shows $2n = 32$ chromosomes of *L. spathulata* stained blue (with DAPI). Image 2 shows the same, with the *L. palustris* genome stained red. Image 3 combines 1 and 2, showing 16 of the 32 chromosomes of *L. spathulata* labeled with a probe of *L. palustris* genome, verifying its hybrid nature. [Ching-I Peng/ Y. Kono]



▲ **Chamerion angustifolium** Fireweed (*Chamerion angustifolium*), one of the most photographed plants in western North America, often forms large stands of striking magenta blooms, like this in Alaska. Its common name derives from its ability to colonize rapidly after fires and other disturbances, using strong underground growth and producing millions of airborne seeds. [J. & N. Dewitt]

MBG's Peter Hoch (author of text):
Peter Hoch arrived in St. Louis in 1972 to become Dr. Peter Raven's first doctoral student at Washington University, where he received his Ph.D. in 1978. He formally joined the Garden staff in 1977, working primarily on *Epilobium* in North America, and later in New Zealand, China, and the former Soviet Union. He has gradually expanded his research to the whole family Onagraceae, often in collaboration with other former students of Dr. Raven.

Science and Conservation at the Missouri Botanical Garden

With operations in over 38 countries around the globe, the Missouri Botanical Garden collaborates with local institutions wherever Garden botanists conduct research and field work, providing technical expertise, assistance with fund raising, and better communication with the worldwide scientific community.

The research division consists of 46 Ph.D. botanists assisted by 144 support staff and 22 graduate students. Studies concentrate on the plants of Meso- and South America, sub-Saharan Africa, Madagascar, China, Vietnam, and North America.

Individual Garden scientists are specialists in the plants of particular regions, in the systematics and evaluation of major plant families, and in the interactions between plants and people.

The Garden serves as the headquarters for the Center for Plant Conservation and for several major collaborative publications, such as *Flora of China* and *Flora Mesoamericana*.

Visit our website: www.mobot.org

An Onagraceae Pollinator

Illustration of the vine hawkmoth (*Eumorpha vitis*) on *Ludwigia erecta*. This hawkmoth gets its common name from feeding as a larva on wild grapes and its relatives, as well as on *Ludwigia*. Adult hawkmoths are important pollinators of many species of *Oenothera*, the evening primrose in the Onagraceae family.

© 2010 Missouri Botanical Garden. Illustration from *The natural history of the rarer lepidopterous insects of Georgia* by James Edward Smith and John Abbot (London: T. Bensley, 1797).
The Missouri Botanical Garden maintains one of the world's finest botanical libraries, including over 6,500 rare books. Select illustrations are available as fine art prints for purchase at the Missouri Botanical Garden Press website www.mbgpress.org. View the entire collection of digitized rare books online at www.illustratedgarden.org.